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Dynamic Logistics Enabled by IoT

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Dynamic Logistics Enabled by IoT

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The Department of Logistics and Intermodal Transportation.

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ABSTRACT

The implementation of Internet of Things technology is becoming increasingly popular in the logistics industry due to its promise of valuable payoffs. The benefits will span across the entire logistics value chain, and benefits from IoT implementation will also impact areas such as operational efficiency, safety, security, and customer experience, while redesigning traditional business models. This report specifically focuses on creating a dynamic logistics system using the Internet of Things. The findings of this report focus on the associated cost savings between traditional logistics systems, and a daily dynamic model enabled by IoT technology. By applying IoT to logistics operations we can begin to approach difficult operational and business questions in smart, innovative ways. Optimizing how people, systems, and assets work together through the implementation of IoT will further redefine business processes and ultimately, advanced analytics will be applied to the entire value chain to identify wider improvement opportunities and best practices.

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Introduction to the Internet of Things

In today's society, the Internet is often considered a "given" due to its constant presence and growing influence on the ways we live, work, and communicate with each other. The Internet has undergone numerous stages of development, dating back to the days where the internet was fundamentally about connecting computers. However, we have since entered a different period in the life of the Internet called the Internet of Things (IoT). IoT is not an entirely new concept, since it originated in the early 2000s. While there are several varying definitions, the simplest way to think of IoT is to consider it the networked connection of physical objects.

With the development of IoT, Internet connections can extend to physical objects that are not computers in the original sense and have the potential to serve a multitude of other purposes. For example, a forklift is used to move pallets or other heavy items. A connected forklift could alert a warehouse manager to an impending mechanical problem or safety risk, or be used to create a smarter, faster, more accurate location intelligence of inventory in a warehouse. Although forklifts have not traditionally been connected to the Internet and did not send, receive, process or store information, there is valuable potential information to be gained from connecting the unconnected, creating new potential insights and business value.

However, we are only at the very beginning of the IoT revolution. According to a study by DHL and Cisco, "So far, less than one percent of all physical objects that could be connected to the Internet are currently connected. In numbers, that means of the roughly 1.5 trillion items on earth that could benefit from an IP address, just under 15 billion are connected to the Internet today… By 2020, Cisco estimates there will be more than 50 billion devices connected to the Internet. By that time, computers (including PCs, tablets, and smartphones) will represent just 17 percent of all Internet connections; the other 83 percent will result from IoT, including wearables and smart-home devices." (6). Although one percent does seem like a low rate of current penetration, IoT deployments have drastically escalated in the past six years. In a study by Zebra Technologies and Forrester Research, "enterprise IoT deployments have grown by 333 percent since 2012. 65 percent of respondents had deployed IoT technologies in the enterprise in 2014, compared to only 15 percent in 2012." (7).

While technical and policy issues are still developing, many factors have contributed to the more recent accelerating deployment of IoT capabilities. The four main contributing factors I have found to be contributing to the growth of the IoT industry is sensor cost, affordable and widespread internet availability, processing power, cloud computing, and mobility. Sensor cost has rapidly declined since the early 2000's. Over the years, Internet access has become so widespread and affordable, there are few places on earth without Internet access. This makes the ability to send, share, and receive information from devices much more achievable. Since computers have progressively become more technologically advanced, the evolution of computing power shows no signs of slowing. Combining these "super computers" with the cloud, we are able to accept huge volumes of data, process it, and perform complicated analytics to provide us answers within seconds. Lastly, with the growing mobility of wireless computers at our fingertips, we are almost always connected and can access unparalleled amounts of data in real time.

IoT in Logistics

IoT promises sweeping payoffs for the logistics industry. The benefits will extend across the entire logistics value chain, including warehousing operations, freight transportation, and last-mile delivery. The benefits from IoT implementation will also impact areas such as operational efficiency, safety, security, customer experience, and aid in developing new business models. Applying IoT to logistics operations promises a substantial impact and we can begin to approach difficult operational and business questions in innovative new ways. Bringing into play the new developments, we can monitor the status of assets, parcels, and people in real time throughout the entire value chain as well as measure how these assets are performing. We can further automate business processes, eliminate manual interventions, improve quality and predictability, and lower costs. Optimizing how people, systems, and assets work together, and coordinating their activities through the implementation of IoT will further redefine business processes and ultimately we will be able to apply analytics across the entire value chain to identify wider improvement opportunities and best practices. DHL defines this as "sensing and sense making. Sensing is the monitoring of different assets within a supply chain through different technologies and mediums; "sense making" is concerned with handling vast amounts of data sets that are generated as a result, and then turning this data into insights that drive new solutions." (6).

Today, we see prime conditions for IoT to take off in the Logistics industry. As previously mentioned, there is a technology push through the rise of mobile computing, 5G networks, big data analytics, as well as a pull from customers who have increasingly high demands for higher fill rates and delivery accuracy. Combined, these factors are driving logistics providers to transition into IoT solutions at an accelerating rate. The supply chain and logistics sector of IoT are estimated to provide $1.9 trillion in value. This is a promising indication of the potential from utilizing IoT in the logistics industry.

This report specifically focuses on creating a dynamic logistics system with the Internet of Things. The costs associated with the dynamic system is then compared to the costs of an original case solution, and a traditional monthly aggregated demand model. The data used is from an academic case study written by Lawrence Gross, and prepared for the Intermodal Association of North America. Below is an abstract of the Academic Case Study, Monroe Supply Hardware.

Monroe Supply Hardware

Academic Case Study

Introduction/Background:

Monroe Supply Hardware is a regional retailer of building and home improvement products headquartered in Cleveland, Ohio. The company operates a network of 65 retail outlets based primarily in the State of Ohio but includes locations in Kentucky, Indiana and Pennsylvania. The privately held company began in 1900 when George Monroe opened the Monroe Hardware and Supplies store in the town of Akron, Ohio. Monroe's timing was convenient; that year Harvey S. Firestone also arrived in town and it was only a few years later that Firestone inked a deal to supply tires to an up-and-coming manufacturer of automobiles named Henry Ford. Akron became a prosperous manufacturing center that was the main source of tires for the U.S. auto industry. Monroe's hardware enterprise flourished, relocating three times over the next 30 years to larger locations.

After George Jr. returned and rejoined Monroe Hardware and Supplies as President, the trend of home construction boomed. George Jr. wanted to capitalize on the trend, so he simplified the company's name to Monroe Supply Hardware and began to open branch locations. Once this decision proved to be successful, the company continued this strategy, expanding across northern Ohio. To service the rising number of locations a large multi-story warehouse was built in Akron, with plenty of room to accommodate growth. However, the continued growth was straining the traditional management techniques and technologies that the conservative MSH management knew and was comfortable with. Large national retailers began to intrude on the MSH territory, bringing lower costs, overseas sourcing and pricing pressures. In 1985, the third generation of the Monroe family took over, when George Jr.'s oldest son Bill assumed the Presidency, with George stepping up to be Chairman. Two of Bill's siblings also filled key roles, with Jack Monroe filling the role of VP Operations and younger sister Amy taking on product and promotion as VP Merchandising. Together, the team decided to meet the challenge of the national big-box retailers head-on, by expanding the company's footprint while streamlining operations. Small downtown locations were closed in favor of larger stores with ample parking, and the company aggressively expanded its store network throughout the region. Jack undertook a transformation of MSH's business processes and was an early adopter of distributed computer systems and personal computers. Amy broadened the MSH product line and her buyers began to venture overseas to source lower-cost products.

The strategy succeeded to a great extent, but that very success led to new problems, primarily in what was then known as the Warehousing and Traffic Department. The big warehouse in Akron was straining at the seams with volume. The multi-story building had high handling costs in part due to having to move merchandise from floor to floor with elevators, and the urban location was not ideal. After extensive study it was decided to establish a new state-of-the-art single level distribution center (often referred to as the "DC" for short). The new location was in Dublin, OH, northeast of Columbus, just off the I-270 Beltway on U.S. 33. The location was chosen in order to minimize the truck miles needed to serve MSH's retail network. The new DC opened in 1995 and proved to be an effective means of reducing logistics costs.

Over the years MSH has continued to evolve. In 2005 Bill Monroe retired and Amy stepped into the CEO role. Brother Jack, always interested in computers, was intrigued by the development of a new communications technology known as the "Internet" and the MSH website was created in 2002. The Traffic Department became the Logistics Department and eventually, the Supply Chain Management Group. Sourcing of many products moved overseas and MSH developed close working relationships with suppliers in order to minimize inventory and drive out costs. These close working relationships enabled MSH to develop a private label line of products under the title "MSH Best" that provided good value to customers at very competitive price points. A complete review of the company's transportation strategy was undertaken and the company began to experiment with intermodal transportation with an eye towards reducing costs.

MSH Best:

1. **MSH Best "Real Feel" Artificial Christmas Tree (lighted).** MSH introduced this product several years ago and it had proven to be a high seller. It featured branches with soft, realistic needles and LED lights, was easy to set up and resulted in a 7.5' tall tree with a diameter at the base of 60". Sales have been increasing by 20% per year on average, with year-to-year growth varying from 10% to 30% depending on the economy and the wallets of holiday shoppers. The Real Feel Tree was a high-margin product for MSH and management wanted to sell as many as possible. But at the same time, overstocking was undesirable, as trees left in inventory after the holiday had to be sold at a steep discount of 50% or more. As might be expected, sales

were highly seasonal with demand concentrated in the period from mid-October to mid-December.

2. **MSH Best "Killer Chiller" Mini Fridge.** This small 2.7 cu. ft. mini fridge had proven popular with students and apartment dwellers. Homeowners also used them as semi-portable units to provide cold beverages on the patio or in the backyard. Sales were somewhat seasonal with the high point in the summer and the back to school season. The biggest sales locations were in the Columbus area as mini-fridges were close to a "required item" for many Ohio State dorm rooms.

3. **MSH Best "Home Pro" 5-Tool Cordless Combo Kit.** The "DIY" (Do It Yourself) market had always been an important segment to MSH. The "Home Pro" line was aimed at the serious DIY user and contained five heavy-duty cordless power tools (drill, reciprocating saw, circular saw, impact driver and work light) all in a convenient carrying case. The Home Pro Combo Kit was a steady seller without heavy seasonal aspects and was regarded as one of the "old reliable" offerings in the MSH Best product line.

4. **MSH Best Fasteners.** A hardware store needs to carry nuts and bolts and the like, and MSH locations were no exception. Hardware of various sizes was packaged in boxes containing quantities of 50 to 200 units, in turn these were packed in standard-size cartons. The weight of these cartons varied somewhat but for the purpose of determining shipping parameters, an average weight had been determined that history had proven to be sufficiently accurate and

consistent to avoid problems. Fasteners were a low-margin item and volumes were steady throughout the year.

Situation:

MSH is looking to cut transportation costs by taking a deep dive into all current routing options. Some factors that need to be taken into consideration include carton size & weight, value and projected sales (see Exhibits 1 and 2). The Chinese suppliers were responsible for loading their product into an ISO shipping container and delivering it to the port of Hong Kong, ready for shipment. MSH assumed ownership of the goods after they passed through the gate at the Port of Hong Kong. The inventory inside of the containers hit MSH's balance sheet at the same time. There was therefore great interest on the part of the Finance Department with regard to transit times and the carrying cost of the inventory. Typically, merchandising wanted product to arrive at the Distribution Center at least 30 days prior to the beginning of anticipated month of sale, to permit orderly movement of the product to individual outlets and to provide safety stock for unanticipated surges in demand.

MSH was responsible for arranging and covering the cost of transport of the cargo from the Port of Hong Kong through to the Dublin Distribution Center. MSH was also responsible for specifying to the exporter what size container to load for the journey and the load configuration within the container, including whether the load should be palletized or hand stacked, and how much product to load into each container. Also provided is information regarding shipping rates and service parameters for a number of options for getting the product from China to Ohio.

Transport Options:

The normal mode for transporting all the products was containerized ocean carrier. MSH had negotiated an annual contract with a global container carrier under the terms of which the freight would move. This carrier had an extensive network and offered a number of options to consider. As is typical today, the carrier was part of a global container line alliance in which several competing carriers had agreed to collaborate. In a manner similar to code-sharing on the airlines, the members of the alliance made their ship capacity available to one another, so that one carrier's container could be carried on the ships of any alliance member. This provided greater frequency of departure to the shipper.

Like almost all ocean carriers, MSH's ocean carrier had adopted the practice of "slow steaming". By adopting a slower standard operating speed and optimizing the configuration of its ships for slower speeds, significant reductions in fuel consumption and operating cost were gained. It had become critical for the ocean carrier to possess the lowest possible cost structure given the commodity-like nature of the ocean freight marketplace and slow-steaming produced the lowest cost per container mile. However, it also had negative effects in terms of longer transit times for shippers.

Equipment Choice:

MSH specified the size of the container to be used for each product (Exhibit 3). Three sizes of ocean containers were available: 20', 40', and 40' Hi-Cube. Each container carried a different freight rate, with larger units commanding higher rates. The amount of cargo that could be loaded into a container was limited by either the physical dimensions of the container (often referred to as "cubing out") or its weight capacity (referred to as "weighing out") depending on the product.

Every ISO container was rated for a maximum gross weight (MGW) which included both the weight of the container itself (tare weight) plus the weight of the payload. For 20' containers the typical MGW was 24,000 kg (53,000 lb.) and for 40' containers the total was 30,480 kg (67,000 lb.). Each container was built with sufficient structure to support a stack of eight additional fully loaded containers in order to permit such arrangements when the containers were loaded in the hold of the ship.

In practice the maximum load capacity of the container was further limited by U.S. highway laws. Trucks were limited to a Gross Combination Weight (GCW) of 80,000 lb., including the weights of the tractor, chassis, container and payload. Therefore the maximum legal payload permitted would be 80,000 pounds minus the tare weights of the tractor, chassis and container.

Routing Options:

The ocean carrier would load the container in Hong Kong onto one of its ships or a vessel belonging alliance partner, unload it at the destination port in the U.S. or Canada and arrange for the transfer to the appropriate railroad intermodal terminal (either "on-dock" or "near-dock"). There the container would be loaded onto a double-stack railcar and moved via intermodal unit train to an intermodal terminal convenient to the DC. The ocean carrier contracted with the railroad to move large quantities of containers and thereby obtained a good rate. Once at the destination terminal the ocean carrier would then provide the local trucking (also known as the "dray") to the DC. The container would normally travel under bond from the port to the inland intermodal terminal and would clear customs there before traveling on the highway to the DC.

Rather than having the ocean carrier manage the delivery all the way to the Distribution Center loading dock, MSH preferred the option of terminating the carrier's move at the intermodal terminal and handling the final leg of the journey itself. This offered the possibility of reducing cost.

There were a number of options for routing the container. Each had different service characteristics and costs. Options existed to bring the container into either the east coast or west coast of North America. Generally, east coast routings were more costly in terms of ocean freight but they saved money on the shorter inland transport. The ocean voyage to the East coast was quite a bit longer than that to the west coast.

Moves that involved west coast ports required the interchange of the railcar/container from the western railroad to an eastern railroad in Chicago. This could either occur by routing the railcar from the western road to the tracks of the eastern road (steel wheel interchange) or by unloading the container in the western road's Chicago-area terminal, driving it across town to the eastern road's Chicago terminal and loading it on another railcar for the final rail movement to Columbus. This was known as a "rubber tire interchange" or a "crosstown dray".

Information on the options is contained in the Exhibits 4 and 5 and is also outlined below:

- **Movement via Los Angeles/Long Beach.** Ocean transport direct from Hong Kong to Southern California. Transfer of the container to double-stack railcar via on-dock rail intermodal facility. Movement by western railroad intermodal unit train to Chicago.

  - **Option A:** Interchange in Chicago to eastern railroad, rail to Columbus, dray from Columbus intermodal ramp to MSH Distribution Center.
  - **Option B:** Truck from Chicago intermodal terminal direct to Dublin
- **Movement via Prince Rupert.** Ocean transport direct from Hong Kong to Prince Rupert, BC. Transfer of the container to double-stack railcar via on-dock rail intermodal facility. Movement by Canadian railroad intermodal unit train to Chicago. Truck from Chicago intermodal terminal direct to Dublin. Steel wheel interchange not available.
- **Movement via New York / New Jersey.** Ocean transport direct from Hong Kong to NY/NJ via Panama Canal. Local dray to rail intermodal terminal near the dock. Transfer of the container to double-stack railcar and movement by intermodal unit train to Columbus intermodal terminal. Local dray from intermodal terminal to DC.
- **Movement via Norfolk.** Ocean transport direct from Hong Kong to Norfolk, VA via Panama Canal. Local dray to rail intermodal terminal near the dock. Transfer of the container to double-stack railcar and movement by intermodal unit train to Columbus intermodal terminal. Local dray from intermodal terminal to DC.

Transload Option:

Another option available to MSH was transloading. For transloading the import ocean container was routed onto a ship calling at the ports of Los Angeles or Long Beach. Once unloaded from the ship it was pulled over the highway to a transloading facility located in Long Beach. This facility was located in the "Heavy Container Corridor", a designated network of highways and streets surrounding the ports on which heavy trucks were permitted. On these streets, trucks pulling containers of 40’ in length or greater were permitted to weigh 95,000 lb, i.e. 15,000 lb. more than the normal 80,000 lb. limit. Thus, the container could be loaded with 15,000 pounds more payload than normal.

At the transload facility the international container would be unloaded and the cargo reloaded into a domestic unit. Normally this would be a 53’ domestic container provided by MSH’s domestic intermodal provider. The transload facility charged MSH a combined rate for the dray from the port plus the transfer of the cargo. This rate differed depending on a number of factors including whether the cargo was on pallets or not and whether it was a standard or overweight load (see Exhibit 6).

Once the cargo was transloaded into the intermodal provider’s domestic container, that carrier would then take responsibility for transporting the domestic container to the nearest rail intermodal terminal, paying the railroad for the transportation of the container to the Midwest and finally, moving the box via highway from the Midwest intermodal terminal to the MSH Dublin facility using its tractors and drivers. This service occurred under a single door-to-door rate that covered the entire movement from the transloading facility to the Dublin, OH DC.

Transloading offered several advantages to MSH. Since the 53’ domestic container was considerably larger than the typical 40’ ISO container, for cube (low density) cargo, two 53’s could often carry the same amount of cargo as three 40’s. This saved on drayage cost and possibly, rail line-haul costs as well (although the rail rate per 53’ container was higher than that for a 40’). For denser product, overweight 40’ containers could be shipped in from Asia and then the load reduced during the transload process for onward movement to Ohio in street legal form. The potential also existed to put together mixed loads of different products. By combining light and heavy products in the same container, the load could be optimized and the maximum amount of product per container could be achieved. Lastly, if product had been delayed and was needed in a hurry to replenish depleted store inventories, the option existed to load the product in a trailer and move it directly to Dublin using a driver team. This could save days of transit time at a much lower cost than flying the product to Ohio.

Transloading, however, also involved additional costs. The product had to be handled at the transloading facility, for which the transloader levied a charge. There was the potential for damage due to additional handling of the product. The transload option involved two highway moves in Los Angeles that could be avoided if the import container was placed directly on the train at the port.

Problem to Solve:

The background has been provided on four MSH Products. The first task is to develop an optimal routing plan for the four products. The second task is to provide a cost summary and a cost analysis for the solution, including the main strategic considerations made in developing the optimal routing plan.

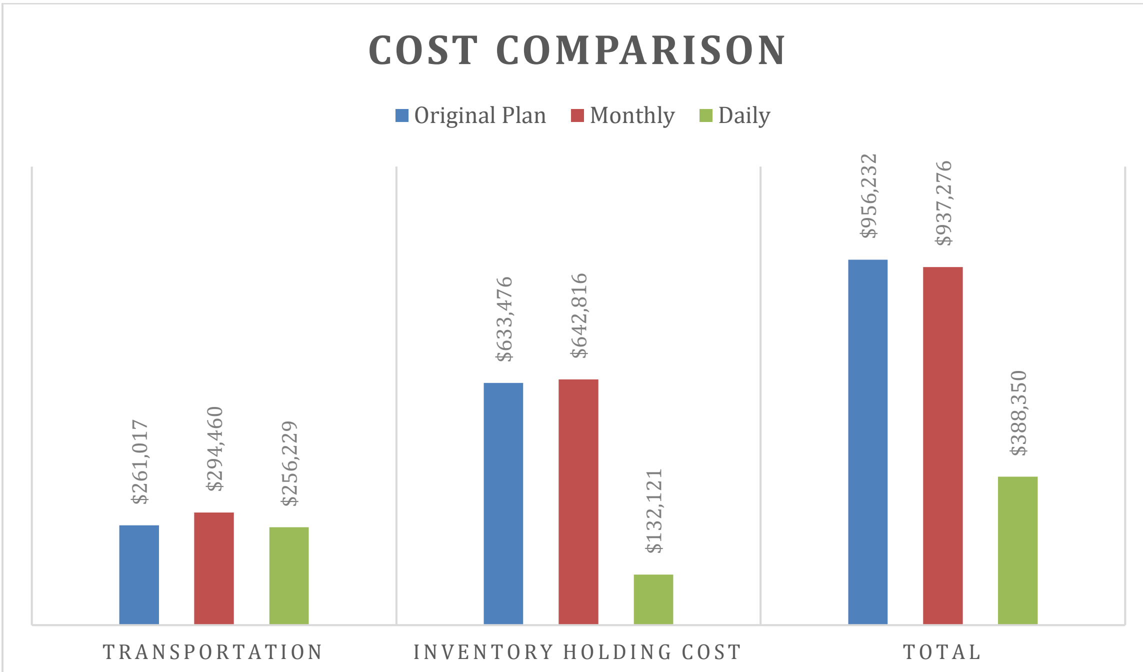
Case Solution: A Dynamic Routing plan Enabled by the Internet of Logistics and IoT Technology

Analysis

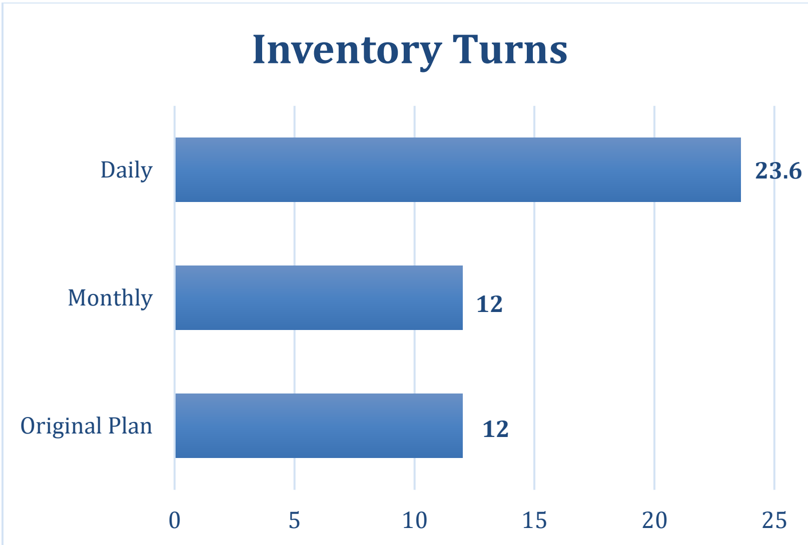
Using the data given in the exhibits of the case study, we have created an original case solution developed for the case competition, a monthly aggregated demand model, and a daily dynamic model, all through Microsoft Excel. In the original solution developed for the competition, certain rules about not mixing containers in Hong Kong had to be followed. Therefore, in our original case solution, we chose route 4 with the transloading option using 40' containers. This was the most cost effective, while satisfying the lead time demands. The annual transportation cost for our original plan is $261,017, and the annual inventory holding cost is $633,476.

The next model we developed is the monthly aggregated demand model. First, the cases demanded for each product are converted to number of pallets needed. The total number of pallets for the four products is calculated for each month. The monthly required pallets are pulled forward based on the company's desired one month of on hand inventory and an average lead-time of approximately 25 days. Using this information, the number of required 40' containers is calculated and then rounded to the nearest integer. The difference between the integer containers and the actual containers is used to determine whether pallets should be delayed or pulled from the next month. If a sufficient number of pallets is delayed, a 20' container is shipped. Again, pallets will be pulled from the next month's shipping plan to fill the 20' container. The shipping costs are calculated based on the average intermodal cost per 40' and 20' container. Inventory holding costs are estimated using the average landed value of a pallet and the number of pallets in inventory. A twenty percent inventory holding cost rate is assumed. For our monthly model, the annual costs are fairly similar to the original plan. The transportation costs total to $294,460 annually, and the inventory holding cost is $642,816.

Lastly, we developed a daily dynamic logistics model by converting monthly demand to daily pallet demand. For each product, we first converted yearly case demand to monthly case demand, and then converted this monthly demand to weekly demand. Weekly demand is smoothed by taking a 5 period moving average. This reduces the abruptness between the transition from one month to the next. Weekly demand is then converted to daily, and this daily demand is used to "build pallets". The units are pulled from the next day in order to create a full pallet. Consolidating in Shanghai increases utilization and those associated cost savings from standard container and palletized loads. All calculations are made assuming a 40' container size. For the Shipping Simulation part of our daily dynamic model, the Ohio Warehouse has a desired inventory level based on the lead-time and a safety factor -- demand during lead-time safety factor. When the actual inventory drops below the desired inventory, the warehouse tells the consolidator to ship a container. The container is then packed based on the forecast for the required products. The container arrives in the port after the "Ocean Lead Time". Following arrival at the port, the container arrives at the warehouse after the "Land Lead Time. The pallets in the container are added to inventory. Holding cost, both warehouse and in transit, is calculated for each day using the "average value of a pallet" in inventory. While transportation costs are slightly lower than the previous two models, the real savings from this dynamic model come from the massive reduction in inventory holding costs. Through developing a daily model, we are able to drastically reduce inventory holding costs. Compared to our original solution, the daily dynamic model saves $501,355 annually on inventory holding costs, with total savings of $567,882 per year. In addition, the dynamic model proves to have a 99.2% fill rate, exceeding the common demand of 99%.



Using the daily dynamic model, inventory turnover nearly doubles, due to the lower amount of excess inventory. The original and monthly aggregated demand models both show inventory turnover of 12. Both original and monthly models require inventory to be stored for a much longer time compared to the daily dynamic model.



Technology Enablers

Anticipatory logistics is powered by big data-based predictive algorithms. What anticipatory logistics does is enable logistics providers to enhance and optimize process efficiency and service quality, and therefore shorten delivery times by predicting demand before a request or order is placed. In addition, supply chain risk concepts can further optimize logistics operations. Anticipatory logistics continues to be primarily driven by increasing customer demand for shorter lead times and higher fill rates. Anticipatory shipping and smart capacity planning can be used by retailers who have analyzed their customers' purchasing behaviors to predict an order before it occurs. For example, MSH has acquired and analyzed data on the growth and seasonality of their products and is therefore able to anticipate demand for the upcoming year. This data is used to be able to create a dynamic model such as the one above, which saves MSH hundreds of thousands of dollars per year. Smart capacity planning using anticipatory algorithms can be used to match the accurate level of logistics resources to meet demand. Smart capacity planning can be used to accurately predict the required logistics capacity for peak shopping seasons, such as the holiday season purchasing spike in the Real Feel Christmas Trees.

This can then be used to move goods to distribution centers in a more just-in-time fashion, saving large sums of money each year in inventory holding costs. In addition, the predictive supply chain risk management capabilities support the shipper in detecting risks in potential damages to cargo. For example, a sensor can monitor shock movements from handling and travel, to allow the shipper to take corrective action and minimize operational delays. If mini fridges were prone to high shock movement levels, causing 2% of mini fridges to be defective upon arrival, MSH could take corrective action by ordering extra inventory to ensure they would not stock out.

The Logistics industry is being redesigned through the power of data-driven information. Due to the growing degree of digitization, unparalleled amounts of data can now be captured from sources along the supply chain. Using big data offers great potential to optimizing capacity utilization, reducing risk, and redesigning traditional business models in logistics. Big data has already begun to be utilized in the logistics industry by turning huge volumes of data into a valuable asset in increasing efficiency in areas like capacity planning and vehicle route optimization. Big Data, combined with the advancement of analytics technologies will further enhance data-driven operating and business models, such as, anticipatory logistics. To relate big data to MSH, operational efficiency could be improved by using big data to increase speed and transparency in decision making, as well as mitigating risk by detecting, evaluating, and alerting all potential disruptions. For example, correlating data such as shipment information, weather, traffic, growing port congestion, etc., can enable real-time scheduling of shipments, optimization of load sequences, and the most accurate prediction of the estimated time of arrival.

Digital product identifiers enable all products to be identifiable, traceable, and locatable from the time they are produced to the time they are sold. Smart labels are perhaps the most crucial addition for complete visibility of a supply chain; they contain information that can be digitally captured and retrieved. For example, MSH can equip each product’s packaging with a disposable smart label. With detailed information regarding that specific product’s origin, shipment date, destination, special requirements (e.g. not rotating a mini fridge onto its side), and destination, the concept of a connected supply chain with complete transparency and traceability becomes much more tangible. With sensor technology cost continuously decreasing over the years, the concept of having disposable smart labels with active sensors is becoming an increasingly real way to have complete visibility over a supply chain, without the high costs.

Summary

The shift towards a more dynamic model is enabled by advancements in IoT technology. Big data, anticipatory logistics models, and digital product identifiers are just a few of the IoT enabled technologies redesigning the Logistics industry and have the potential to provide huge cost savings to companies. Through developing a more dynamic logistics system, inventory holding costs can be drastically decreased, and companies can maintain a 99%, or higher, fill rate. In the Monroe Supply Hardware case, the dynamic model saves $501,355 annually on inventory holding costs, with total savings of $567,882 per year. In an even more large-scale company, these savings will only be larger.

Conclusion

Rob Siegers, President Global Technology at DHL Customer Solutions & Innovation, states “The Internet of Things represents $1.9T in Value at Stake for the logistics industry over the next ten years. Bountiful opportunities therefore exist for logistics providers to leverage IoT in their organizations in order to increase productivity, reengineer existing processes and provide new services that challenge traditional business models. However, to derive significant commercial value from IoT will ultimately depend on how well connected assets, such as containers or parcels, are networked along the entire supply chain. This of course entails close cooperation and collaboration between all players in the logistics industry”

The implementation of IoT technology is becoming increasingly popular in the logistics industry due to its promise of valuable payoffs. The benefits will expand across the entire logistics value chain, and benefits from IoT implementation will also impact areas such as operational efficiency, safety and security, customer experience, and aid in developing new business models. By applying IoT to logistics operations we can begin to approach difficult operational and business questions in smart, innovative ways. We can further automate business processes, eliminating manual interventions, improving quality and predictability, and lowering costs. Optimizing how people, systems, and assets work together, and coordinating their activities through the implementation of IoT will further redefine business processes and ultimately, we will be able to apply analytics to the entire value chain to identify wider improvement opportunities and best practices.

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Appendix

Exhibit 1 – MSH Best Product Shipping Specifications

MSH Best Product Shipping Specifications

Item	"Real Feel" Christmas Tree	"Killer Chiller" Mini Fridge	"Home Pro" Tool Kit	Hardware
Length (Inches)	39	19.5	30	23
Width (Inches)	22	18.375	15	19
Height (Inches)	22	27.125	12	11
Weight (lb)	53	44	30	70
Wholesale Cost	\$ 275	\$ 99	\$ 300	\$ 80
Retail Price	\$ 550	\$ 159	\$ 449	\$ 95

Exhibit 2 – MSH Best Product Sales Projections

MSH Best Product Sales Projections				
Annual Volume/Store	25	30	45	104
Estimated Annual Volume	2300	2760	4140	9568
Safety Stock	10%	10%	10%	5%
Starting Inventory (April 1)	0	50	50	100
Distribution by Month				
Apr	0%	7%	7%	8.3%
May	0%	7%	7%	8.3%
Jun	0%	7%	7%	8.3%
Jul	0%	11%	7%	8.3%
Aug	0%	10%	7%	8.3%
Sep	5%	14%	9%	8.3%
Oct	20%	14%	11%	8.3%
Nov	40%	10%	11%	8.3%
Dec	30%	5%	11%	8.3%
Jan	5%	5%	9%	8.3%
Feb	0%	5%	7%	8.3%
Mar	0%	5%	7%	8.3%
Total	100%	100%	100%	100%

Exhibit 3 – Equipment Specifications

Equipment Specifications				
Containers	20' ISO	40' ISO	40' High Cube ISO	53' Domestic
Cubic Capacity	1,170	2,391	2,700	3,932
Tare Weight	4,740	8,250	8,700	10,300
Internal Length	19' 4"	39' 6"	39' 6"	52' 6"
Internal Width	7' 9"	7' 9"	7' 9"	8' 2-5/8"
Internal Height	7' 10"	7' 10"	8' 10"	9' 1-3/8"
External Length	19' 10-1/2'	40' 0"	40' 0"	53' 0"
External Width	8' 0"	8' 0"	8' 0"	8' 6"
External Height	8' 6"	8' 6"	9'6"	9' 6-1/2"
Door Opening Width	7' 8"	7' 8"	7' 8"	8' 2"
Door Opening Height	7' 6"	7' 6"	8' 6"	9' 1-3/8"
Chassis	20' Slider Chassis	20' Tri-Axle Chassis	40' Chassis	53' Chassis
Maximum GCW (lb)	69,800	80,000	80,000	80,000
Tare Weight	6,700	11,200	7,200	7,900

Exhibit 4 – Drayage Costs

Drayage Costs

Distance (Mi)	Rate	
0-25	$ 145	
26-50	$ 190	
51-75	$ 235	
76-100	$ 285	
101+	$1.45 per Mile, All Miles	
Fuel Surcharge applies to all rates		
Chassis Rental applies to all rates		
Standard 20'/40'	$ 25	per day
20' Tri-Axle	$ 35	per day
2 Days per Load Minimum		
Tractor/Driver Detention Charges		
2 hours free time included in rate		
Per Addit. Hour	$ 60	

Fuel Surcharge Percentage

DOE Low	DOE High	Percent	DOE Low	DOE High	Percent
$1.960	$1.999	10.00%	$3.560	$3.599	30.00%
$2.000	$2.039	10.50%	$3.600	$3.639	30.50%
$2.040	$2.079	11.00%	$3.640	$3.679	31.00%
$2.080	$2.119	11.50%	$3.680	$3.719	31.50%
$2.120	$2.159	12.00%	$3.720	$3.759	32.00%
$2.160	$2.199	12.50%	$3.760	$3.799	32.50%
$2.200	$2.239	13.00%	$3.800	$3.839	33.00%
$2.240	$2.279	13.50%	$3.840	$3.879	33.50%
$2.280	$2.319	14.00%	$3.880	$3.919	34.00%
$2.320	$2.359	14.50%	$3.920	$3.959	34.50%
$2.360	$2.399	15.00%	$3.960	$3.999	35.00%
$2.400	$2.439	15.50%	$4.000	$4.039	35.50%
$2.440	$2.479	16.00%	$4.040	$4.079	36.00%
$2.480	$2.519	16.50%	$4.080	$4.119	36.50%
$2.520	$2.559	17.00%	$4.120	$4.159	37.00%
$2.560	$2.599	17.50%	$4.160	$4.199	37.50%
$2.600	$2.639	18.00%	$4.200	$4.239	38.00%
$2.640	$2.679	18.50%	$4.240	$4.279	38.50%
$2.680	$2.719	19.00%	$4.280	$4.319	39.00%
$2.720	$2.759	19.50%	$4.320	$4.359	39.50%
$2.760	$2.799	20.00%	$4.360	$4.399	40.00%
$2.800	$2.839	20.50%	$4.400	$4.439	40.50%
$2.840	$2.879	21.00%	$4.440	$4.479	41.00%
$2.880	$2.919	21.50%	$4.480	$4.519	41.50%
$2.920	$2.959	22.00%	$4.520	$4.559	42.00%
$2.960	$2.999	22.50%	$4.560	$4.599	42.50%
$3.000	$3.039	23.00%	$4.600	$4.639	43.00%
$3.040	$3.079	23.50%	$4.640	$4.679	43.50%
$3.080	$3.119	24.00%	$4.680	$4.719	44.00%
$3.120	$3.159	24.50%	$4.720	$4.759	44.50%
$3.160	$3.199	25.00%	$4.760	$4.799	45.00%
$3.200	$3.239	25.50%	$4.800	$4.839	45.50%
$3.240	$3.279	26.00%	$4.840	$4.879	46.00%
$3.280	$3.319	26.50%	$4.880	$4.919	46.50%
$3.320	$3.359	27.00%	$4.920	$4.959	47.00%
$3.360	$3.399	27.50%	$4.960	$4.999	47.50%
$3.400	$3.439	28.00%	$5.000	$5.039	48.00%
$3.440	$3.479	28.50%	$5.040	$5.079	48.50%
$3.480	$3.519	29.00%	$5.080	$5.119	49.00%
$3.520	$3.559	29.50%	$5.120	$5.159	49.50%

* DOE Weekly Retail On-Highway Diesel U.S. East Coast Average Fuel Index can be found at http://tonto.eia.doe.gov/oog/info/wohdp/diesel.asp.

* If the U.S. East Coast Average Fuel Index equals or exceeds $5.12 per gallon, the fuel surcharge increases 0.5% for every 4-cent increase in fuel price.

Exhibit 5 – Routing Options

Routing Options

Intact

Option	Ocean Segment			Inland Segment 1		Inland Segment 2		IPI Cost			Final Delivery		
	Origin	Destination Port	Est. Transit Days	Terminal	Est. Transit Days	Terminal	Est. Transit Days	20' Container	40' Standard	40' Hi-Cube	Miles to DC	Est. Transit Days	Total Est. Days
1	Hong Kong	Prince Rupert, BC	16	Chicago	5	Columbus	5	$ 2,670	$ 4,450	$ 4,690	13	1	27
1	Hong Kong	Prince Rupert, BC	16	Chicago	5	N/A		$ 2,400	$ 4,000	$ 4,240	289	2	23
2	Hong Kong	Los Angeles/Long Beach	19	Chicago	6	Columbus	5	$ 2,550	$ 4,250	$ 4,490	13	1	31
3	Hong Kong	Los Angeles/Long Beach	14	Chicago	6	N/A		$ 2,280	$ 3,800	$ 4,040	305	2	22
4	Hong Kong	Norfolk (via Suez)	31	Columbus	3	N/A		$ 2,460	$ 4,100	$ 4,340	33	1	35
5	Hong Kong	NY/NJ (via Panama)	32	Columbus	4	N/A		$ 2,400	$ 4,000	$ 4,240	13	1	37

Transload

Option	Ocean Segment			Transload		Inland Segment		Ocean / Transload Cost			Inland Cost	
	Origin	Destination Port	Est. Transit Days	Terminal	Est. Transit Days	Destination	Est. Transit Days	20' Container	40' Standard	40' Hi-Cube	53' Domestic	Total Est. Days
Ocean	Hong Kong	Los Angeles/Long Beach	19					$ 1,320	$ 2,200	$ 2,440		
Transload				Long Beach	2			See Transload Charges				
Via Intermodal						Dublin, OH	5				$ 2,500	26
Via Truck (Team Driver)						Dublin, OH	2				$ 5,200	23

Exhibit 6 – Transloading Costs

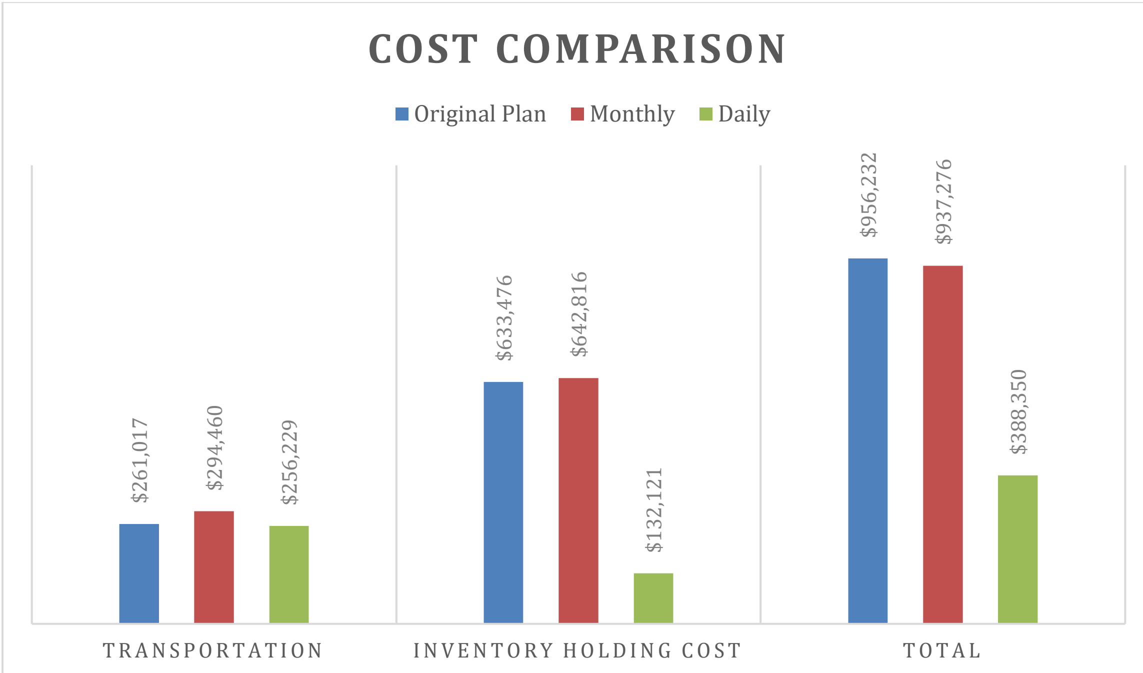
Transloading Costs

Item	Cost	Notes
Transload Regular	$ 550	Includes drayage from port & transload, return of empty container to port. Load must be palletized
Transload Floor Loaded	$ 850	Includes drayage from port & transload, return of empty container to port, for hand stacked loads
Transload Overweight	$ 750	Includes drayage from port & transload, return of empty container to port. Load must be palletized
Transload Overweight Floor Loaded	$ 1,000	Includes drayage from port & transload, return of empty container to port, for hand stacked loads
Chassis Rental	$ 25	Per day, 2 day minimum, applies to all loads
Port Terminal Time	$ 60	per hour, two hours free included above
Palletize floor-loaded freight	$ 18	per pallet

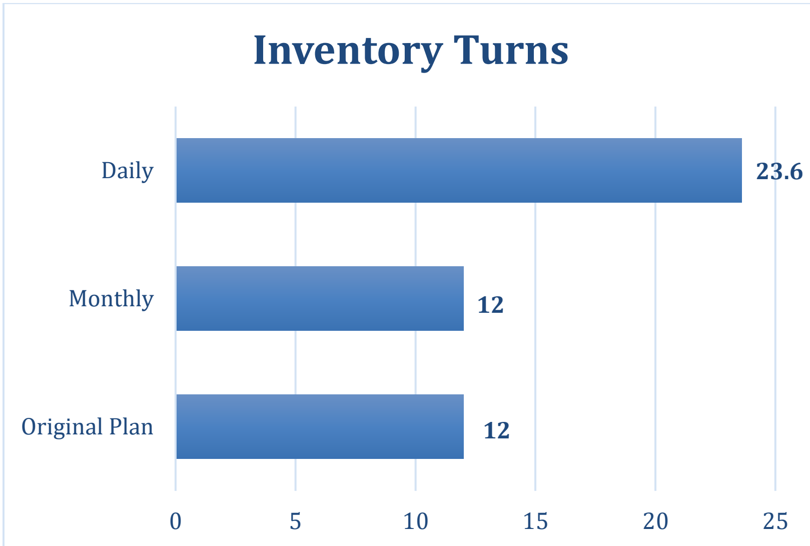
Dublin Distribution Center Unloading Costs

Item	Cost	Notes
Palletized 20' Container	$ 35	
Palletized 40' Container	$ 60	
Palletized 53' Container/Trailer	$ 85	
Floor Loaded 20' Container	$ 180	
Floor Loaded 40' Container	$ 300	

Cost Comparison Chart



Inventory Turns Comparison Chart



Original Case Solution Costs

Transloading Cost					
	Regular Freight Cost			Transloading Cost	Total
	Containers	Containers	Containers	Containers	
	20	40	40HC	53	
Mar-18	$ 2,905.45	$ -	$ -	$ 13,810.00	$ 16,715.45
Apr-18	$ -	$ -	$ -	$ 16,351.67	$ 16,351.67
May-18	$ 2,905.45	$ -	$ -	$ 13,810.00	$ 16,715.45
Jun-18	$ -	$ 4,630.45	$ -	$ 7,545.00	$ 12,175.45
Jul-18	$ -	$ -	$ -	$ 13,570.00	$ 13,570.00
Aug-18	$ -	$ 4,630.45	$ -	$ 20,875.00	$ 25,505.45
Sep-18	$ 2,905.45	$ -	$ -	$ 28,340.00	$ 31,245.45
Oct-18	$ 2,905.45	$ -	$ -	$ 42,630.00	$ 45,535.45
Nov-18	$ -	$ -	$ -	$ 44,230.00	$ 44,230.00
Dec-18	$ -	$ -	$ -	$ 14,610.00	$ 14,610.00
Jan-19	$ 2,905.45	$ -	$ -	$ 13,810.00	$ 16,715.45
Feb-19	$ -	$ -	$ -	$ 14,610.00	$ 14,610.00
Mar-19	$ -	$ -	$ -	$ -	$ -
Apr-19	$ -	$ -	$ -	$ -	$ -
Total Transportation	$ 14,527.25	$ 9,260.90	$ -		$ 261,017.00
Annual Inventory Holding					$ 633,476.00
Total Annual Cost					$ 956,232.00

Monthly Aggregated Demand Model and Costs

	Monthly Aggregated Demand Shipping Plan												
	April	May	June	July	August	September	October	November	December	January	February	March	April
Pallets Required	64	77	77	92	88	125	178	225	174	90	69	69	64
Pallets Shipped	64	78	71	90	84	125	177	225	167	89	74	59	60
40' Containers	3.05	3.71	3.38	4.29	4.00	5.95	8.43	10.71	7.95	4.24	3.52	2.81	2.86
40' Containers Rounded	3	4	3	4	4	6	8	11	8	4	4	3	3
40' Pallets Pulled	0	6	0	0	0	1	0	7	1	0	10	4	3
40' Pallets Delayed	1	0	8	6	0	0	10	0	0	5	0	0	0
20' Containers	0.10	0.00	0.80	0.60	0.00	0.00	1.00	0.00	0.00	0.50	0.00	0.00	0.00
20' Containers Rounded	0	0	1	1	0	0	1	0	0	1	0	0	0
20' Pallets Pulled	0	0	2	4	0	0	0	0	0	5	0	0	0
20' Pallets Delayed	0	0	0	0	0	0	0	0	0	10	0	0	0
Pallets Pulled	0	6	2	4	0	1	0	7	1	5	10	4	3
Pallets Delayed	1	0	0	0	0	0	0	0	0	10	0	0	0
40' Cost	$ 6,600	$ 8,800	$ 6,600	$ 8,800	$ 8,800	$ 13,200	$ 17,600	$ 24,200	$ 17,600	$ 8,800	$ 8,800	$ 6,600	$ 6,600
20' Cost	$ -	$ -	$ 1,320	$ 1,320	$ -	$ -	$ 1,320	$ -	$ -	$ 1,320	$ -	$ -	$ -
Total	$ 6,600	$ 8,800	$ 7,920	$ 10,120	$ 8,800	$ 13,200	$ 18,920	$ 24,200	$ 17,600	$ 10,120	$ 8,800	$ 6,600	$ 6,600

Ocean	**$ 141,680**

	April	May	June	July	August	September	October	November	December	January	February	March	April
Pallets Shipped	63	84	73	94	84	126	178	231	168	94	84	63	63
53' Trailers	1.97	2.63	2.28	2.94	2.63	3.94	5.56	7.22	5.25	2.94	2.63	1.97	1.97
53' Trailers Rounded	2	3	2	3	3	4	6	7	5	3	3	2	2
Pallets LTL	0	0	9	0	0	0	0	7	8	0	0	0	0
Cost	$ 5,000	$ 7,500	$ 6,800	$ 7,500	$ 7,500	$ 10,000	$ 15,000	$ 18,900	$ 14,100	$ 7,500	$ 7,500	$ 5,000	$ 5,000

Land	**$ 112,300**

Total Transportation Cost	**$ 294,460**
Total Inventory Holding Cost	**$ 642,816**
Total Annual Cost	**$ 937,276**

Daily Dynamic Shipping Model - Snapshot

	Value per Pallet																			
	$ 1,650	$ 792	$ 5,400	$ 2,240	$ -		Pallets / Container		20	Leadtime in Days		14	Leadtime in Days		6		Safety Factor			1.5
	$ 3,300	$ 1,272	$ 8,082	$ 2,660			Consolidation			Shipping										Last
	Demand									Maritime			Land			Ending Inventory				Sales
Day	Christmas Tree	Mini Fridge	Tool Kit	Hardware	Other	**Total**	China	xxxx	Total	Port	xxxx	Total	Ohio	xxxx	Total	Desired	Whse	xxxx	Total	
																	100			
1						**0**	0		0			0			0		100		100	0
2	0	1	1	1	0	**3**	0		0			0			0	76.5	97		97	0
3	0	1	0	1	0	**2**	0		0			0			0	76.5	95		95	0
4	0	1	1	1	0	**3**	0		0	0		0			0	76.5	92		92	0
5	0	0	0	1	0	**1**	0		0	0		0	0		0	76.5	91		91	0
6	0	1	1	1	0	**3**	0		0	0		0	0		0	78	88		88	0
7	0	1	0	1	0	**2**	0		0	0		0	0		0	78	86		86	0
8	0	1	1	1	0	**3**	0		0	0		0	0		0	78	83		83	0
9	0	1	1	1	0	**3**	0		0	0		0	0		0	76.5	80		80	0
10	0	1	0	1	0	**2**	0		0	0		0	0		0	76.5	78		78	0
11	0	1	1	1	0	**3**	20		20	0		0	0		0	76.5	75		75	0
12	0	1	0	1	0	**2**	0		0	0		0	0		0	76.5	73		73	0
13	0	0	1	1	0	**2**	0		0	0		0	0		0	76.5	71		71	0
14	0	1	0	1	0	**2**	0		0	0		0	0		0	78	69		69	0
15	0	1	1	1	0	**3**	0		0	0		0	0		0	78	66		66	0
16	0	1	1	1	0	**3**	0		0	0		0	0		0	76.5	63		63	0
17	0	1	0	1	0	**2**	0		0	0		0	0		0	78	61		61	0
18	0	1	1	1	0	**3**	20		20	0		0	0		0	78	58		58	0
19	0	1	0	1	0	**2**	0		0	0		0	0		0	78	56		56	0
20	0	0	1	1	0	**2**	0		0	0		0	0		0	78	54		54	0
21	0	1	1	1	0	**3**	0		0	0		0	0		0	79.5	51		51	0
22	0	1	0	1	0	**2**	0		0	0		0	0		0	79.5	49		49	0
23	0	1	1	1	0	**3**	0		0	0		0	0		0	78	46		46	0
24	0	1	0	1	0	**2**	0		0	0		0	0		0	78	44		44	0
25	0	1	1	1	0	**3**	0		0	0		0	0		0	78	41		41	0
26	0	1	0	1	0	**2**	0		0	20		20	0		0	78	39		39	0
27	0	1	1	1	0	**3**	20		20	0		0	0		0	78	36		36	0
28	0	0	1	1	0	**2**	0		0	0		0	0		0	78	34		34	0
29	0	1	0	1	0	**2**	0		0	0		0	0		0	79.5	32		32	0

Daily Dynamic Model Costs

	Value per Pallet																
	$ 1,650	$ 792	$ 5,400	$ 2,240	$ -		1.5	Inventory Valuation Per Pallet									
	$ 3,300	$ 1,272	$ 8,082	$ 2,660			Last	Value	Shipping Cost Basis			Shipping			Interest		
	Demand						Sales	Per Pallet	Maritime	Land	Holding Cost	Maritime	Land	Sales	Earned	Ending	Lost
Day	Christmas Tree	Mini Fridge	Tool Kit	Hardware	Other	Total		$ 2,238.41	$ 22	$ 15	20%	$ 22	$ 15	$ 3,438.54	5%	Cash	Sales
718	0	1	1	1	0	3	0	$ 8,432	$ 22	$ 15	279	$ -	$ -	$ 12,014	$ 434	$ 3,171,447	$ -
719	0	1	0	1	0	2	0	$ 3,032	$ 22	$ 15	97	$ -	$ -	$ 3,932	$ 434	$ 3,172,684	$ -
720	0	0	1	1	0	2	0	$ 7,640	$ 22	$ 15	235	$ -	$ -	$ 10,742	$ 435	$ 3,175,985	$ -
721	0	1	1	1	0	3	0	$ 8,432	$ 22	$ 15	245	$ -	$ -	$ 12,014	$ 435	$ 3,179,758	$ -
722	0	0	0	1	0	1	0	$ 2,240	$ 22	$ 15	64	$ -	$ -	$ 2,660	$ 436	$ 3,180,549	$ -
723	0	1	1	1	0	3	0	$ 8,432	$ 22	$ 15	225	$ -	$ -	$ 12,014	$ 436	$ 3,184,341	$ -
724	0	1	0	1	0	2	0	$ 3,032	$ 22	$ 15	78	$ -	$ -	$ 3,932	$ 436	$ 3,185,599	$ -
725	0	0	1	1	0	2	0	$ 7,640	$ 22	$ 15	186	$ -	$ -	$ 10,742	$ 436	$ 3,188,952	$ -
726	0	1	0	1	0	2	0	$ 3,032	$ 22	$ 15	71	$ -	$ -	$ 3,932	$ 437	$ 3,190,218	$ -
727	0	1	1	1	0	3	0	$ 8,432	$ 22	$ 15	181	$ -	$ -	$ 12,014	$ 437	$ 3,194,055	$ -
728	0	0	1	1	0	2	0	$ 7,640	$ 22	$ 15	155	$ -	$ -	$ 10,742	$ 438	$ 3,197,440	$ -
729	0	1	0	1	0	2	0	$ 3,032	$ 22	$ 15	58	$ -	$ -	$ 3,932	$ 438	$ 3,198,719	$ -
730	0	0	1	1	0	2	0	$ 7,640	$ 22	$ 15	138	$ -	$ -	$ 10,742	$ 438	$ 3,202,122	$ -
731	0	1	0	1	0	2											
	840	752	500	740	0				Total Transportation Cost		$ 256,229						
					2832				Total Inventory Holding Cost		$ 132,121	20.6% lower than monthly model					
									Total Annual Cost		$ 388,350						